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EP-A- 278 406 **EP-A- 439 876**
JP-A- 1 237 939 **JP-A- 1 315 036**

- **PATENT ABSTRACTS OF JAPAN vol. 5, no. 113 (P-89)13 November 1981 & JP-A-56 107 247 (RICOH CO) 26 August 1981**
- **PATENT ABSTRACTS OF JAPAN vol. 16, no. 493 (P-1435)13 October 1992 & JP-A-04 177 643 (OLYMPUS OPTICAL CO) 24 June 1992**

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a pickup structure for optically reading recorded data from a recording medium.

Description of the Prior Art

In an optical disk player or the like, as shown in Fig. 1A, a light-emitting-receiving composite element called a laser coupler 11 is used in an optical pickup. In the laser coupler 11, photodiodes 13 and 14 are formed on an Si substrate 12, and a prism 15 is fixed on the photodiodes 13 and 14 by an adhesive.

A submount 16 serving as another Si substrate is fixed on the Si substrate 12 by soldering or the like. A photodiode 17 is formed on the submount 16, and a laser diode 21 is fixed on the submount 16 by soldering or the like.

In order to reproduce data recorded on a optical disk 22 using the laser coupler 11, part of light 23 emitted from the laser diode 21 is reflected on a surface 15a of the prism 15, transmitted through an objective lens 24, and incident on the optical disk 22.

The part of the light 23 which is reflected by the optical disk 22, transmitted through the objective lens 24, and incident on the surface 15a of the prism 15 is refracted and enters into the prism 15. The first half of the light 23 which enters into the prism 15 is incident on the photodiode 13, the second half reflected by the photodiode 13 is totally reflected by a surface 15b of the prism 15, and is incident on the photodiode 14.

The photodiode 13, as shown in Fig. 1B, is divided into three parts A, B and C, and the photodiode 14, as shown in Fig. 1C, is divided into three parts D, E and F. An output obtained from these photodiodes 13 and 14 and expressed by:

$$(A + C + E) - (B + D + F)$$

is used as a focus error signal.

Therefore, as described above, 50% of the light 23 which enters into the prism 15 through the surface 15a must be incident on the photodiode 13, and the remaining 50% must be reflected by the photodiode 13.

For this reason, in the conventional pickup used in an unpolarization optical system recording scheme such as an optical disk, as shown in Fig. 2, an optical semitransparent film 25 (half mirror) having a reflectance of 50% is deposited on a portion of the prism 15 opposite to the photodiode 13.

Note that an SiO_2 film 26 serving as a protection film is formed on the surface of the Si substrate 12, and an adhesive layer 27 is interposed between the SiO_2 film 26 and the optical semitransparent film 25 on the photodiode 13. Furthermore, the photodiode 17 receives the light 23 emitted from the rear surface of the laser diode 21 to perform automatic power control.

The refractive indices of the Si substrate 12, the SiO_2 film 26 and the adhesive layer 27 are about 3.5, about 1.5 and about 1.45, respectively, with respect to light having a wavelength of 780 nm. For this reason, about 16% of incident light is reflected by the interface between the Si substrate 12 and the SiO_2 film 26 which have a large refractive index difference, and as shown in Fig. 3, the light 23 is reflected in a multiple form between the interface and the optical semitransparent film 25 to cause multiple interference to occur.

When the light 23 serving as convergent light having incident angles changed according to incident positions is incident on the portion where the multiple interference occurs, bright and dark portions are formed according to the incident angles, and fringes shown in Fig. 4 are formed. Since the fringes are functions of incident angles and wavelengths, when the wavelength of the laser diode 21 is varied by a change in temperature, the fringes move.

The movement of the fringes adversely affect the variable characteristics of the laser coupler 11 as a temperature characteristic, and an optical disk player or the like using the laser coupler 11 is regarded as a defective one under the standards of currently available optical disk players and the like.

As shown in Fig.5, the optical semitransparent film 25 is not formed, and an SiN film 31 having a refractive index of about 2.0 is formed on a portion of the SiO_2 film 26 on the photodiode 13. In this manner, a structure for obtaining the function of an optical semitransparent film by four layers consisting of the adhesive layer 27, the SiN film 31, the SiO_2 film 26 and the Si substrate 12 is also considered.

In this structure in Fig. 5, however, the maximum reflectance is about 40%, and a ratio of the amount of light incident on the photodiode 13 to that on the photodiode 14 cannot be set to be 1 : 1. This ratio of the light amounts may be electrically corrected. However, in this case, noise to the photodiodes 13 and 14 cannot be differentially reduced. That is, an optical optimal point and a signal optimal point do not coincide with each other, thereby degrading the playability

of an optical disk player.

In addition, in order to obtain the structure in Fig. 5, each of the products of the thicknesses and refracting indices of the SiN film 31 and the SiO_2 film 26 must be set to be λ/4 of the light 23. However, the SiN film 31 and the SiO_2 film 26 each having a high-precision film thickness cannot easily be formed in mass production.

Therefore, the above problem cannot be easily solved by the prior art. Although an unpolarization optical system recording scheme is applied to a laser coupler used for an optical disk in which the above laser diode, a microprism and the like are integrally arranged, this recording scheme can be used for only reading data.

Examples of the above mentioned prior art are disclosed in JP 1 237 939 A and JP 1 315 036.

The EP-A-0278406 describes an optical pickup head comprising a substrate on which photodetectors are formed, and an optical member adhered on the photodetectors by an adhesive and including a semi-transmissive reflective film adapted to reflect the light from a laser source and to transmit the light returned from a record medium of a disk, wherein the refractive index of the optical member is larger than the refractive index of the adhesive so as to avoid that "stray light" from the laser source may reach the photodetectors.

In the JP-A-56107247 an image recording method is disclosed wherein a light signal carrying a picture information is exposed to a photosensitive recording medium which is provided with a light absorbing layer between a photoreceptor and a base to prevent multiple reflection in the inside of the photoreceptor.

OBJECTS AND SUMMARY OF THE INVENTION

The present invention is defined in cliam 1.

As the object of the present invention, in a pickup using an unpolarization optical system recording scheme, in order to solve a problem in which about 16% of incident light is reflected by an interface between an Si substrate and an SiO_2 film to cause multiple interference to occur, a light-absorbing film is formed between a light-receiving element and an optical semitransparent film.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood more fully from the detailed description given herebelow and from the accompanying drawings of the preferred embodiments of the invention, however, the drawings are not intended to imply limitation of the invention to a specific embodiment, but are for explanation and understanding only.

Fig. 1A is a side view showing a conventional structure, and Figs. 1B and 1C are plan views showing a photodiode of the conventional structure in Fig. 1A;

Fig. 2 is a side view showing another prior art;

Fig. 3 is an enlarged side view showing a main part of the prior art in Fig. 2;

Fig. 4 is a plan view showing fringes;

Fig. 5 is a side view showing still another prior art;

Fig. 6A is a side view showing the first embodiment of the present invention, and Fig. 6B is an enlarged side view showing a main part of the first embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the present invention will be described below with reference to an unpolarization optical system. The embodiment has the same arrangement as that of the prior art shown in Fig. 2 except that a light-absorbing film 32 is added to an adhesive layer 27 side of an optical semitransparent film 25 as shown in Fig. 6A. Note that the adhesive layer 27 has a thickness of about 10 μm.

According to the above embodiment, when the transmittance of the light-absorbing film 32 is represented by T (< 1), as is apparent from Fig. 6B, the amount of light 23 transmitted through the optical semitransparent film 25 and the light-absorbing film 32 and directly incident on a photodiode 13 is decreased to T times that obtained when the light-absorbing film 32 is not used.

However, the amount of the light 23 reflected in a multiple manner between the optical semitransparent film 25 and the interface between an Si substrate 12 and an SiO_2 film 26 is abruptly decreased to T^3 and T^5 times.... For this reason, multiple interference is suppressed, and fringes shown in Fig. 4 are not easily formed.

At this time, when the reflectance of the optical semitransparent film 25 is represented by R, the amount of the light 23 incident on the photodiode 13 is proportional to $(1 - R) \cdot T$, and the amount of the light 23 incident on a photodiode 14 is proportional to R. Therefore, when R and T are set to satisfy the following equation:

$$T = R/(1 - R),$$

a ratio of the amount of light incident on the photodiode 13 to that on the photodiode 14 can be set to be 1 : 1.

When the reflectance R and the transmittance T are set to be variable values such that the ratio of the amount of light incident on the photodiode 14 is set to be 1 : 1, a ratio of the intensity of the light 23 incident on the interface between the Si substrate 12 and the SiO_2 film 26 to the intensity of the light 23 incident on the optical semitransparent film 25 is actually calculated.

When the amplitude of the light 23 incident on the optical semitransparent film 25 is represented by I_0; the amplitude reflectance of the optical semitransparent film 25, r_h; the amplitude transmittance of the optical semitransparent film 25, t_h; the amplitude transmittance of the light-absorbing film 32, t_a; and the amplitude reflectance of the interface between the Si substrate 12 and the SiO_2 film 26, r_s, the amplitude of the light 23 directly incident on the interface is given by:

$$I_0 \cdot t_h \cdot t_a$$

In addition, the amplitude of the light 23 reflected once by the interface and the optical semitransparent film 25 and incident on the interface again is given by:

$$I_0 \cdot t_h \cdot t_a \cdot r_s \cdot t_a \cdot r_h \cdot t_a \cdot \exp(-i\delta)$$

where δ is a phase difference. When the thickness of an interference film, i.e., three layers consisting of the light-absorbing film 32, the adhesive layer 27 and the SiO_2 film 26 is represented by $\underline{d}$, the refractive index of the three layers is represented by $\underline{n}$, the wavelength of the light 23 is represented by λ, and the incident angle of the light 23 is represented by θ (Fig. 7B), the following equation can be obtained:

$$\delta = (2\pi/\lambda) \cdot 2nd \cdot \cos\theta$$

Therefore, the phase difference δ is changed according to the incident angle θ. In addition, since the phase difference δ depends on the wavelength λ, the phase difference δ is also changed according to the temperature characteristic of a laser diode 21. For this reason, fringes move as described above.

Multiple interference is a sum of the light components described above, and the amplitude of the light 23 incident on the interface between the Si substrate 12 and the SiO_2 film 26 is given by:

$$I = (I_0 \cdot t_h \cdot t_a)/\{1 - t_a^2 \cdot r_s \cdot r_h \cdot \exp(-i\delta)\}$$

As a result, the intensity is given by:

$$|I|^2 = (|I_0|^2 \cdot |t_h|^2 \cdot |t_a|^2)/ [1 + t_a^4 \cdot |r_s \cdot r_h|^2 - 2t_a^2 \cdot \mathrm{Re}\{r_s \cdot r_h \cdot \exp(-i\delta)\}]$$

On the other hand, as described above, since the refractive indices of the Si substrate 12 and the SiO_2 film 26 are about 3.5 and 1.5, respectively, with respect to light having a wavelength of 780 nm, the following value can be obtained:

$$|r_s|^2 = 16\%$$

Therefore, a ratio of the intensity $|I|^2$ of the light 23 incident on the interface between the Si substrate 12 and the SiO_2 film 26 to the intensity $|I_0|^2$ of the light 23 incident on the optical semitransparent film 25 is to be actually calculated. When the light-absorbing film 32 is not used, i.e., when the transmittance T of the light-absorbing film 32 is 100%, and

the reflectance R of the optical semitransparent film 25 is 50%, the intensity ratio is obtained by:

$$|I|^2/|I_d|^2 = 0.5/(1 + 0.5 \times 0.16 - 2 \times 0.283 \times \cos\delta) = 0.5/(1.08 - 0.566\cos\delta)$$

As a result, the intensity ratio ranges from 30.4 to 97.3% according to the value of cosδ.

When the transmittance T of the light-absorbing film 32 is 25%, and the reflectance R of the optical semitransparent film 25 is 20%, the intensity ratio is obtained by:

$$|I|^2/|I_d|^2 = 0.2/(1 + 0.25^2 \times 0.2 \times 0.16 - 2 \times 0.25 \times 0.179 \times \cos\delta) = 0.2/(1.002 - 0.0895\cos\delta)$$

As a result, the intensity ratio ranges from 18.3 to 21.9% according to the value of cos δ.

When the transmittance T of the light-absorbing film 32 is 11.1%, and the reflectance R of the optical semitransparent film 25 is 10%, the intensity ratio is obtained by:

$$|I|^2/|I_d|^2 = 0.1/(1 + 0.111^2 \times 0.1 \times 0.16 - 2 \times 0.111 \times 0.126 \times \cos\delta) = 0.1/(1.0002 - 0.028\cos\delta)$$

As a result, the intensity ratio ranges from 9.7 to 10.2% according to the value of cos δ.

In the above calculations, the difference between the refractive indices of the SiO_2 film 26 and the adhesive layer 27 is small, and the reflectance of the interface therebetween is small, i.e., 0.03%. For these reasons, the reflection of the interface isneglected. Furthermore, it is an assumption that a non-reflective coating is formed between a prism 15 and the optical semitransparent film 25.

As is apparent from the above results, variations in intensity ratio are smaller when the light-absorbing film 32 is used than when the light-absorbing film 32 is not used. Therefore, according to this embodiment, multiple interferende is suppressed, and fringes are reduced. In addition, the optical semitransparent film 25 and the light-absorbing film 32 can be formed on the prism 15 in mass production. An optical optimal point can coincide with a signal optimal point, thereby improving playability.

On the other hand, in this embodiment, unlike the above prior art, an SiN film 31 and the SiO_2 film 26 each having a high-precision thickness need not be formed. The photodiodes 13 and 14 can be formed in a standard process. For this reason, cost can be considerably decreased, and mass production can be performed.

Although the light-absorbing film 32 is independently used in the above embodiment, the adhesive layer 27 may contain a dye to add the function of a light-absorbing film to the adhesive layer 27.

Claims

1. An optical apparatus for optically reading data from a recording medium, comprising :

   a substrate (12),
   first and second photodetectors (13,14) formed on a main face of said substrate (12),
   an optical element (15) having a reflecting surface (15b) which is facing said main face of said substrate,
   an optically semitransparent film (25) formed between said first photodetector (13) and said light reflecting surface (15b), for transmitting part of the light reflected from said recording medium to said first photodetector and reflecting part of said light towards said reflecting surface, said second photodetector (14) being located

for receiving light reflected from said semitransparent film (25) and said reflecting surface (15b); characterised by a light absorbing film (27;32) formed between said first photodetector and said semitransparent film, in order to suppress interference causedby multiple reflections between said semitransparent film and said substrate main face.

2. An optical apparatus according to claim 1, **characterized by** an optical element (15) fixed on said photodetectors for guiding light reflected from said recording medium to said first photodetector and from said first photodetector to said second photodetector and said films (25,32) being formed between said optical element and said photodetectors.

3. An optical apparatus according to claim 2, **characterized in that** said optical element is fixed on said photodetectors through an adhesive layer (27) formed between said photodetector and said films (25,32).

4. An optical apparatus according to claim 3, **characterized in that** said light absorbing film is realised by including in said adhesive layer a dye to have light absorbance.

5. An optical apparatus according anyone of the preceding claims, **characterized in that** the transmittance T of the light absorbing film (32) and the reflectance R of the optically semi-transparent film (25) satisfy the equation $T = R/(1-R)$.

Patentansprüche

1. Optisches Gerät zum optischen Lesen von Daten von einem Aufzeichnungsmedium, mit: einem Substrat (12),

   einem ersten (13) und einem zweiten Photodetektor (14), die auf einer Hauptoberfläche des Substrats (12) geformt sind,
   einem optischen Element (15) mit einer reflektierenden Oberfläche (15b), welche der Hauptoberfläche des Substrats gegenüberliegt,
   einem optisch semitransparenten Film (25), der zwischen dem ersten Photodetektor (13) und der lichtreflektierenden Oberfläche (15b) geformt ist, um einen Teil des von dem Aufzeichnungsmedium reflektierten Lichts zu dem ersten Photodetektor durchzulassen und einen Teil des Lichts in Richtung auf die reflektierende Oberfläche zu reflektieren, wobei der zweite Photodetektor (14) derart angeordnet ist, daß er das von dem semitransparenten Film (25) und der reflektierenden Oberfläche (15b) reflektierte Licht empfängt,

   gekennzeichnet durch

   einen lichtabsorbierenden Film (27; 32), der zwischen den ersten Photodetektor und den semitransparenten Film geformt ist, um Interferenz zu unterdrücken, die durch Mehrfachreflexionen zwischen dem semitransparenten Film und der Substrat-Hauptoberfläche verursacht wird.

2. Optisches Gerät nach Anspruch 1, **dadurch gekennzeichnet, daß** das optische Element (15) auf den Photodetektoren befestigt ist, um das von dem Aufzeichnungsmedium reflektierte Licht zu dem ersten Photodetektor und von dem ersten Photodetektor zu dem zweiten Photodetektor zu leiten, und die Filme (25, 32) zwischen dem optischen Element und den Photodetektoren geformt sind.

3. Optisches Gerät nach Anspruch 2, **dadurch gekennzeichnet, daß** das optische Element auf den Photodetektoren durch eine klebende Schicht (27) befestigt ist, die zwischen die Photodetektoren und die Filme (25, 32) geformt ist.

4. Optisches Gerät nach Anspruch 3, **dadurch gekennzeichnet, daß** der lichtabsorbierende Film dadurch realisiert ist, daß in der klebenden Schicht ein Farbstoff enthalten ist, der eine Lichtabsorption aufweist.

5. Optisches Gerät nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß** das Transmissionsvermögen T des lichtabsorbierenden Films (32) und das Reflexionsvermögen R des optisch semitransparenten Films (25) der Gleichung $T = R/(1 - R)$ genügen.

Revendications

1. Appareil optique pour lire optiquement des données sur un support d'information d'enregistrement, comprenant :

   un substrat (12) ;
   des premier et second photodétecteurs (13, 14) formés sur une face principale dudit substrat (12) ;
   un élément optique (15) comportant une surface réfléchissante (15b) qui fait face à ladite face principale dudit substrat ;
   un film optiquement semi-transparent (25) formé entre ledit premier photodétecteur (13) et ladite surface réfléchissant la lumière (15b) pour transmettre une partie de la lumière réfléchie depuis ledit support d'information d'enregistrement sur ledit premier photodétecteur et pour réfléchir une partie de ladite lumière en direction de ladite surface réfléchissante, ledit second photodétecteur (14) étant placé pour recevoir une lumière réfléchie depuis ledit film semi-transparent (25) et ladite surface réfléchissante (15b),

   caractérisé par un film d'absorption de lumière (27 ; 32) formé entre ledit premier photodétecteur et ledit film semi-transparent afin d'atténuer une interférence générée par de multiples réflexions entre ledit film semi-transparent et ladite face principale de substrat.

2. Appareil optique selon la revendication 1, caractérisé par un élément optique (15) fixé sur lesdits photodétecteurs pour guider une lumière réfléchie depuis ledit support d'information d'enregistrement jusqu'audit premier photodétecteur et depuis ledit premier photodétecteur jusqu'audit second photodétecteur, lesdits films (25, 32) étant formés entre ledit élément optique et lesdits photodétecteurs.

3. Appareil optique selon la revendication 2, caractérisé en ce que ledit élément optique est fixé sur lesdits photodétecteurs par l'intermédiaire d'une couche d'adhésif (27) formée entre ledit photodétecteur et lesdits films (25, 32).

4. Appareil optique selon la revendication 3, caractérisé en ce que ledit film d'absorption de lumière est réalisé en incluant dans ladite couche d'adhésif un colorant de manière à disposer d'une capacité d'absorption de lumière.

5. Appareil optique selon l'une quelconque des revendications précédentes, caractérisé en ce que la transmittance T du film d'absorption de lumière (32) et la réflectance R du film optiquement semi-transparent (25) satisfont l'équation $T = R/(1-R)$.

FIG.1A
PRIOR ART

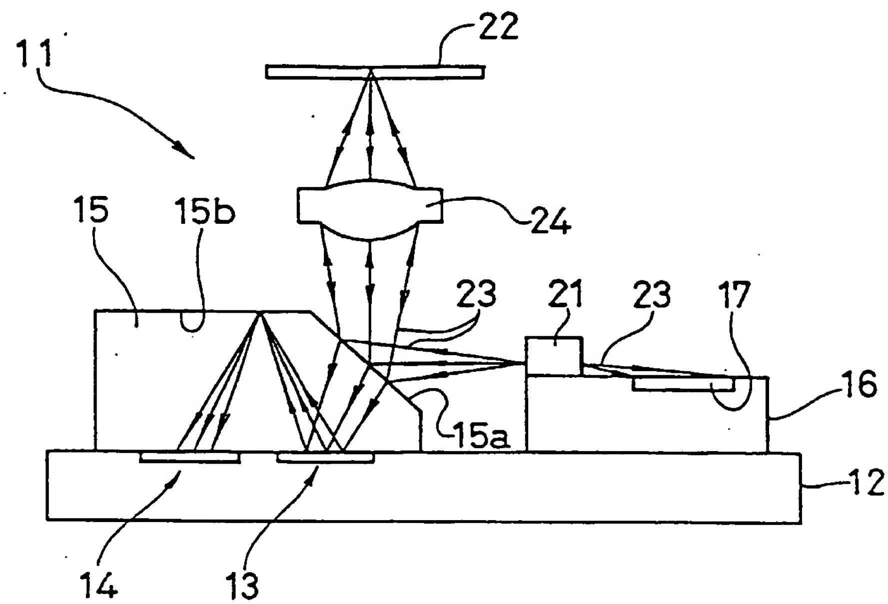

FIG.1B
PRIOR ART

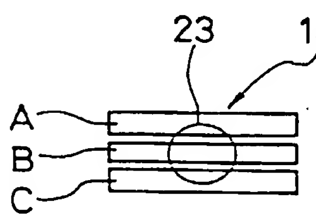

FIG.1C
PRIOR ART

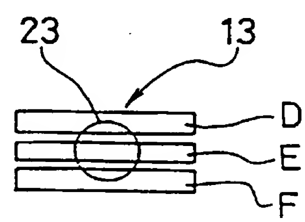

FIG. 2
PRIOR ART

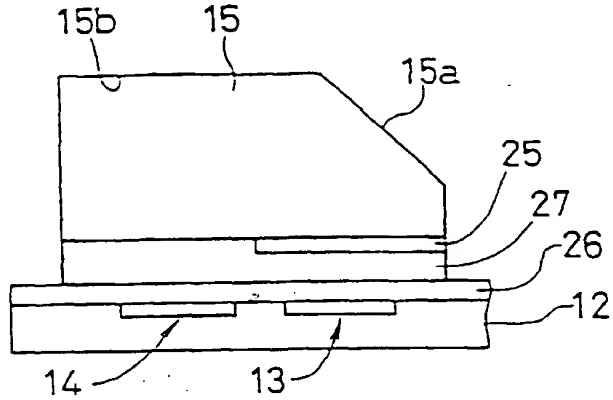

FIG. 3
PRIOR ART

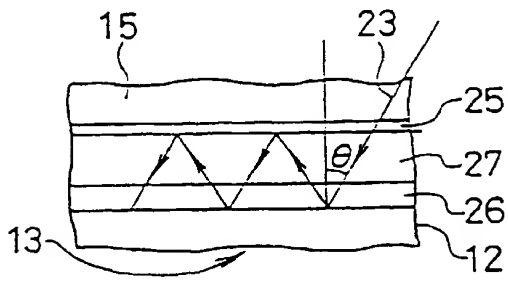

FIG. 4
PRIOR ART

FIG. 5
PRIOR ART

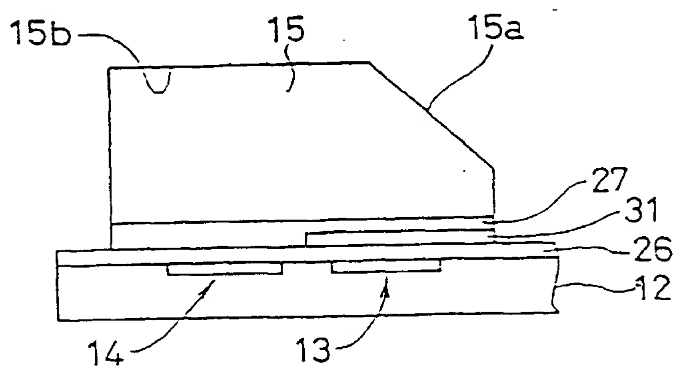

FIG. 6A

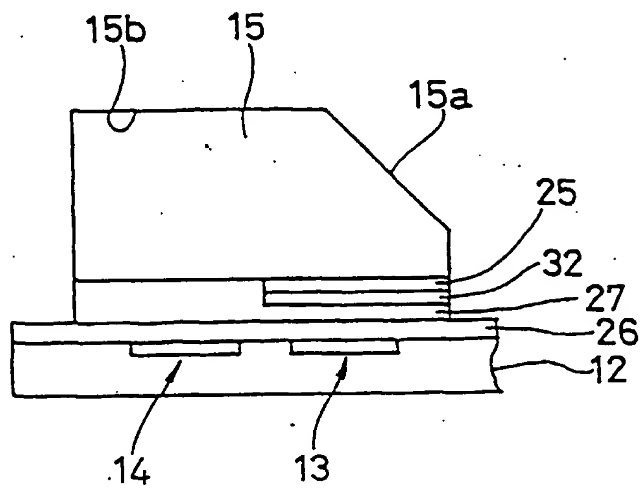

FIG. 6B